NCAR

NARCCAP
North American Regional Climate Change Assessment Program

Multiple AOGCM and RCM Climate Scenarios Project over North America

Linda O. Mearns

CEC Workshop, June 11, 2004

National Center for Atmospheric Research

NARCCAP - Participants

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Ray Arritt, Iowa State, George Boer, CCCma, Daniel Caya, OURANOS, Phil Duffy, LLNL, Filippo Giorgi, Abdus Salam ICTP, William Gutowski, Iowa State, Isaac Held, GFDL, Richard Jones, Hadley Centre, Rene Laprise, UQAM, Ruby Leung, PNNL, Jeremy Pal, ICTP, John Roads, Scripps, Lisa Sloan, UC Santa Cruz, Ron Stouffer, GFDL, Gene Takle, Iowa State, Warren Washington, NCAR, Francis Zwiers, CCCma

NARCCAP Goals

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1. Exploration of multiple uncertainties in regional model and global climate model regional projections,
2. Development of multiple high resolution regional climate scenarios for use in impacts models,
3. Further evaluation of regional model performance over North America;
4. Exploration of some remaining uncertainties in regional climate modeling (e.g., importance of compatibility of physics in nesting and nested models).
5. Creation of greater collaboration between US and Canadian climate modeling groups, as well as with the European modeling community

Program Elements

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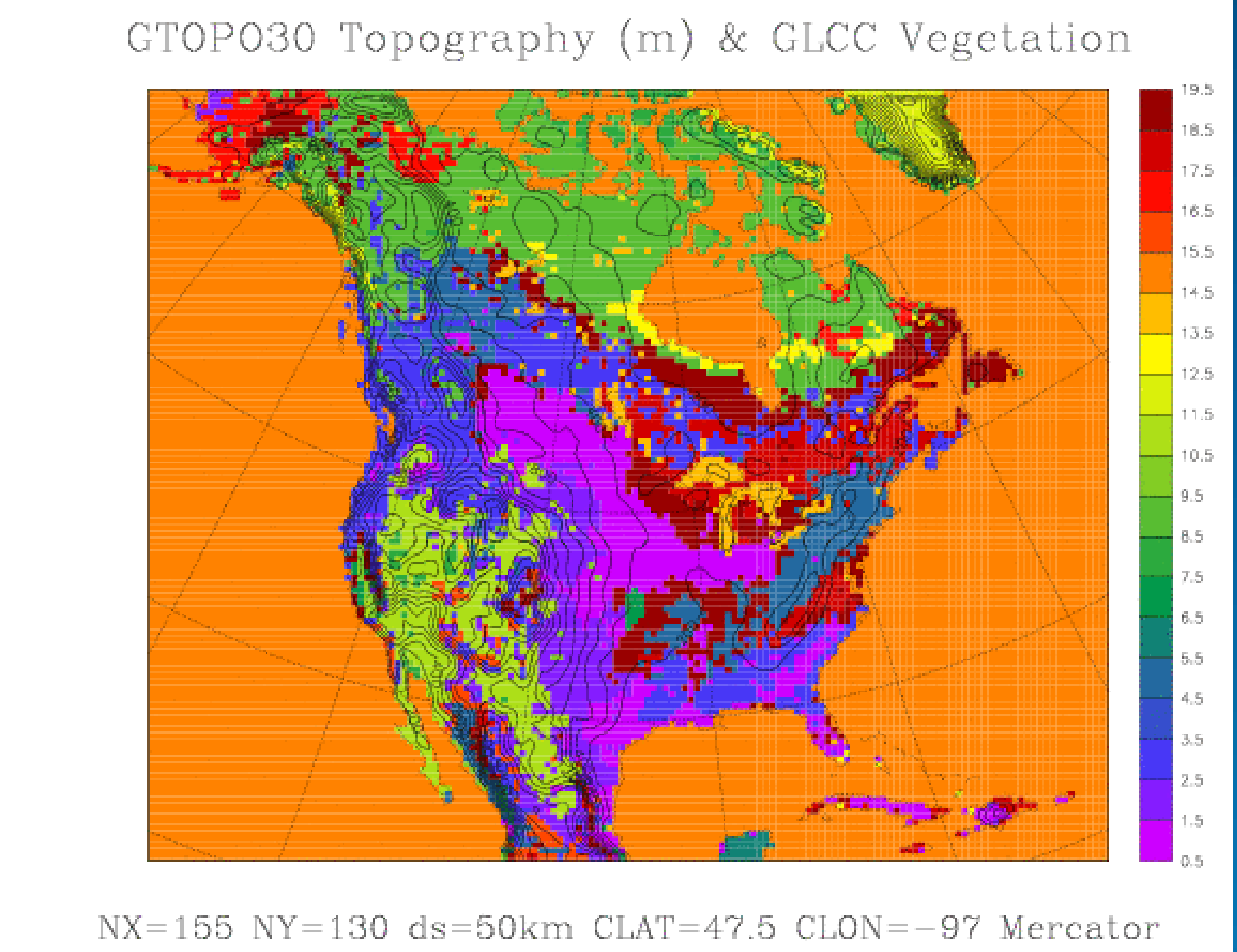
- Four AOGCMs (or their time slices) – NCAR CCSM; Canadian Climate Centre CGCM3; Hadley Center HADCM3 (HadAM3); GFDL AOGCM (with appropriate evaluation)

  Provide boundary condtions for:
- Five RCMs - the Canadian RCM, MM5, HadRM3, RegCM3, and RSM.
- Domain over continental United States and Canada
- The A2 and A1B SRES Emissions Scenarios
- 30 years control, 30 years 2040-2069 (and some later time periods (2070-99)) to correspond with Prudence
- Program is modeled after the PRUDENCE European Program
- Approbation of NSF and CCSP - funding being organized (DOE, NOAA ,EPA,)

NARCCAP domain



Organization of Program

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- Phase I: 10-20 year simulations using NCEP or ECMWF boundary conditions (Iowa State/PIRCS takes organizational lead) – provision of boundary conditions, data storage, initial RCM performance evaluation with major participation of each RCM group).
- Phase IIa: RCM runs (50 km res.) nested in AOGCMs – managed by LLNL and Iowa State.
- Phase IIb: Time-slice experiments at 50 km res. (GFDL and NCAR CAM3). For comparison with RCM runs.
- Opportunity for double nesting (over specific regions) to include participation of other RCM groups e.g., for NOAA OGP RISAs.
- Scenario formation and provision to impacts community led by NCAR and GFDL.

Additional Program Elements

- Observed data sets for model evaluation
  - PIRCS assembled data sets
  - Development of gridded daily observed datasets for validation and eventual use for impacts (e.g., temperature and precipitation), NOAA NCDC (Dave Easterling), and in Canada Stephen Lambert, CCCma

- Initial experimental design and characterization of uncertainty across simulations - formal statistical models (e.g., Tebaldi et al., 2004). Effort led by NCAR (D. Nychka, GSP).

NCAR Weather and Climate Impacts Assessment Science Initiative

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www.assessment.ucar.edu

- Characterizing Uncertainty in the Assessment Process
- Ananlyzing, modeing, of extreme evetns and their impacts
- Climate and health integrated program

Quantification of Uncertainty in Projections of Regional Climate Change: A Bayesian Approach

Tebaldi et al. ***J. of Climate (accepted*****)**
http://www.cgd.edu/~tebaldi/BayesREA.pdf

- Extension of Giorgi and Mearns (2002) REA method
- Prior distributions specified for all random quantities
- Final product is posterior distributions of climate change

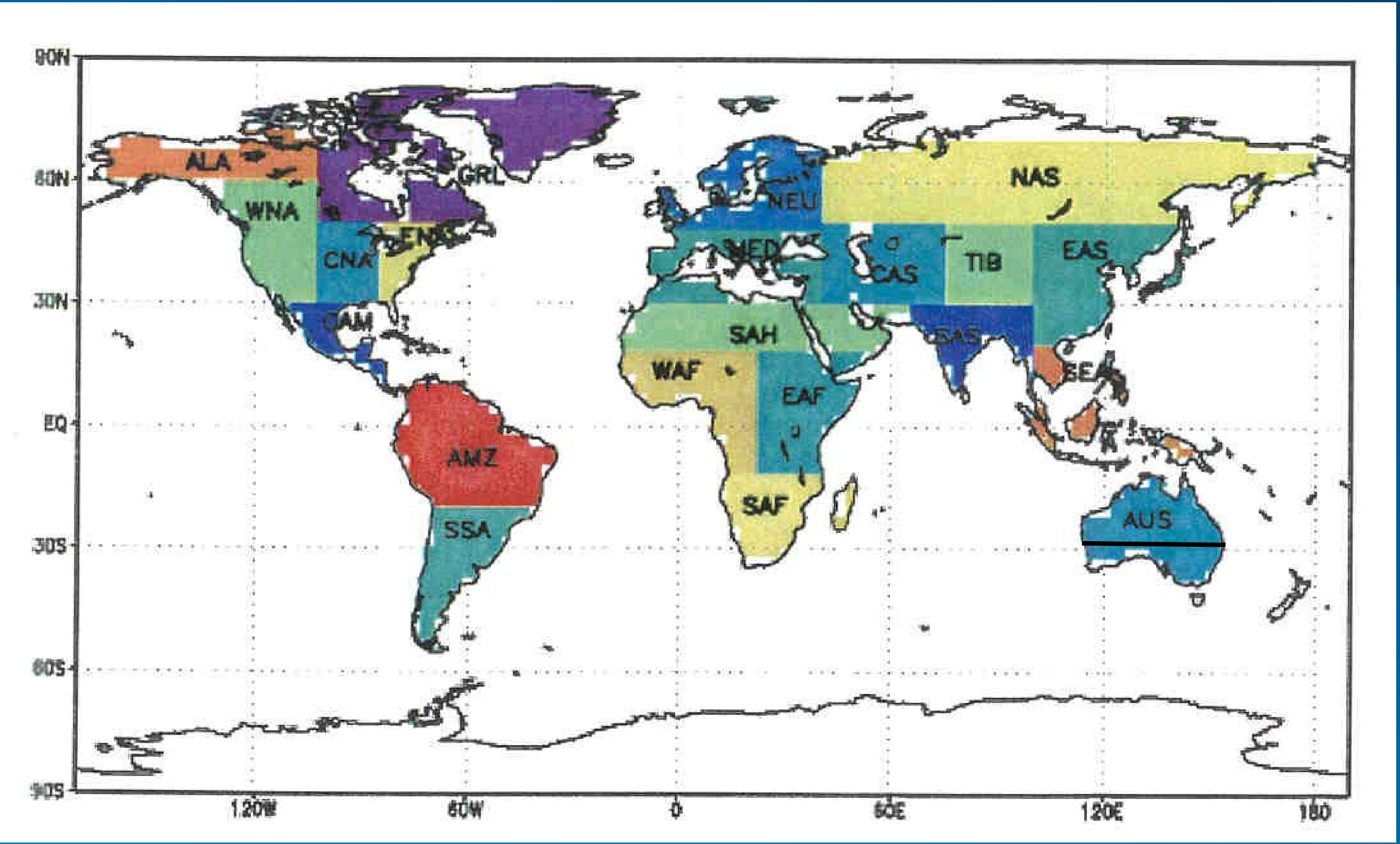
Giorgi and Mearns 'REA' Method,

J. Climate 15: 1141-1158, 2002

- Summary measure of regional climate change based on weighted average of climate model responses
- Weights based on model 'reliability'
- Model Reliability

  Criteria:

  - Performance of AOGCM (bias)
  - Model convergence (for climate change)



Regions used in the analysis presented in this work. SAU, NAU, AMZ, SSA, CAM, WNA, CNA, ENA, ALA, GRL (and northern territories), MED, NEU, WAF, EAF, SAF, SAH, SEA, EAS, SAS, CAS, TIB, and NAS. Giorgi and Francisco (2000) provide the regions' definition in terms of lat. and lon.

Combining Multi-Model Ensembles

Consider the results of several models as a sample from a hypothetical super population of models:

$$X_j = \mu + e_j$$

$$Y_j = \nu + \varepsilon_j$$

j= 0: observed data j=1, M: the M models

X: current climate Y: future projection

μ and ν: true values

The variance in the errors is determined based on principles of model *bias* and model *convergence* (Giorgi and Mearns, 2002).

Method Overview

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- Parameters of interest (e.g., μ, v, and λ) are treated as random variables
- Chose priors for λ, θ, μ, v

  λ and θ = Gamma distribution
  μ and v = Uniform distribution
- Develop joint density distributions of parameters of interest by combining likelihoods and priors
- To move from joint density to posterior distributions for parameters of interest, perform a Markov Chain Monte Carlo simulation, and then look at the empirical distributions of sample values

Posterior Distributions for Current and Future Winter Temperatures (DJF) for Central Asia

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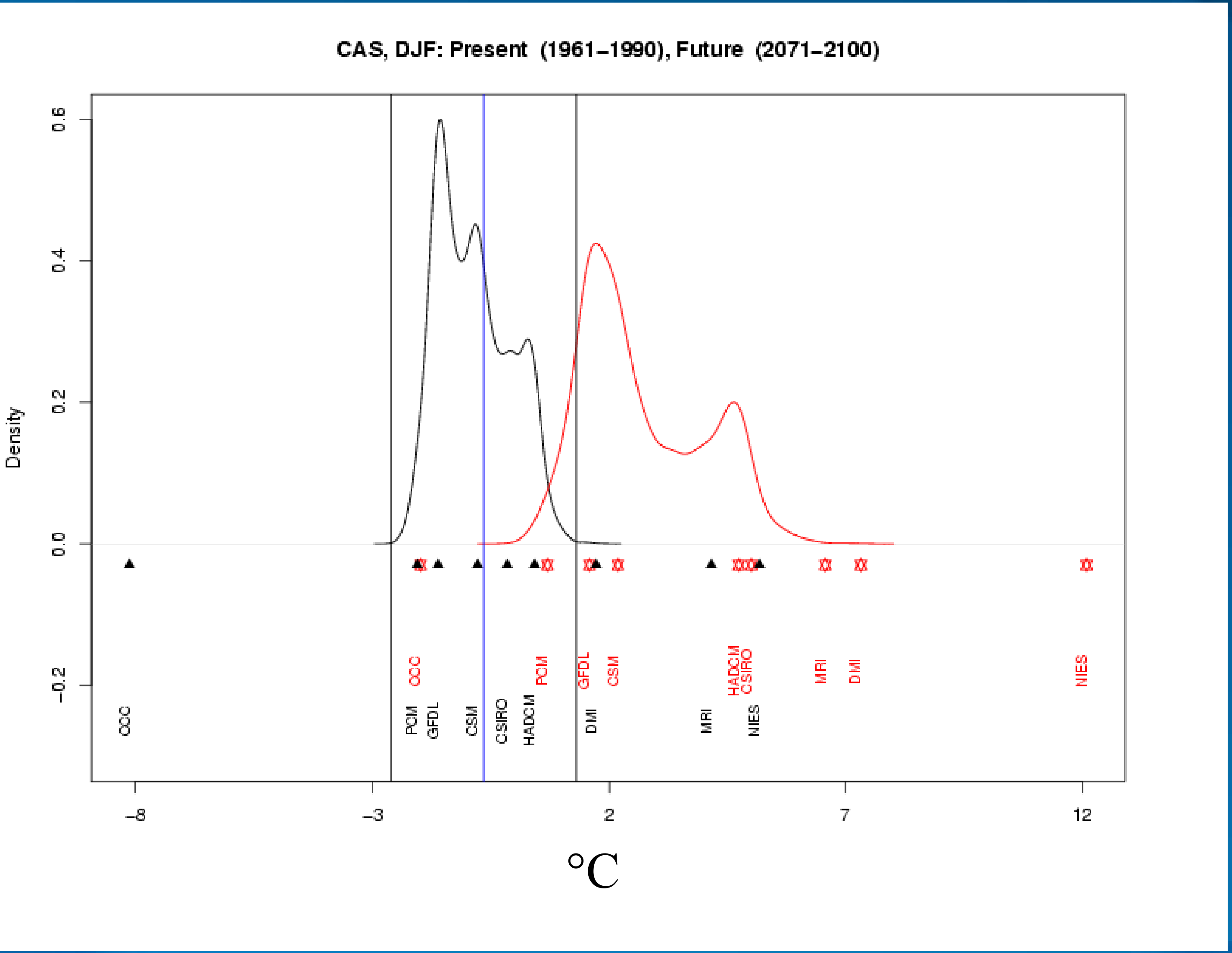
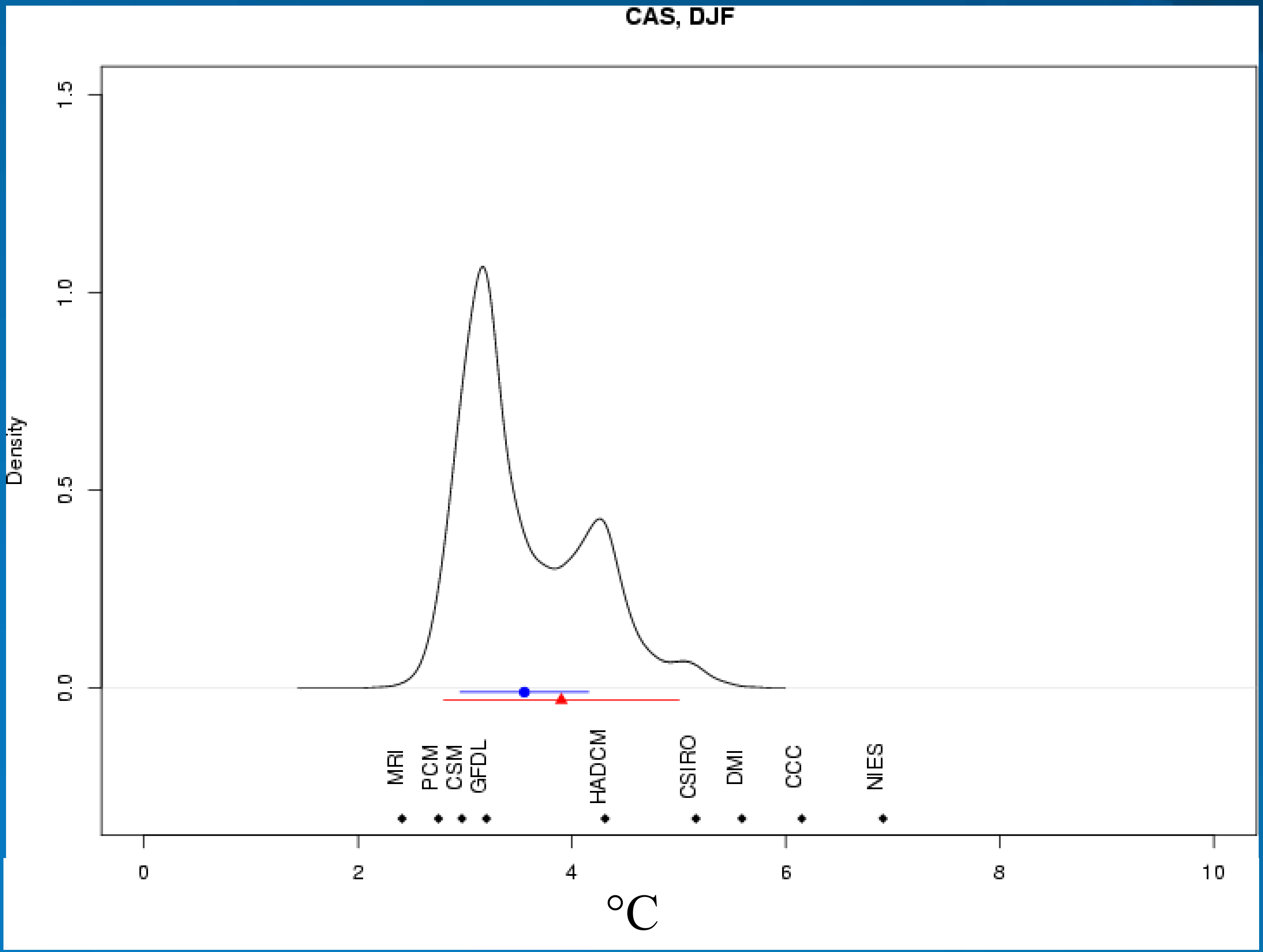
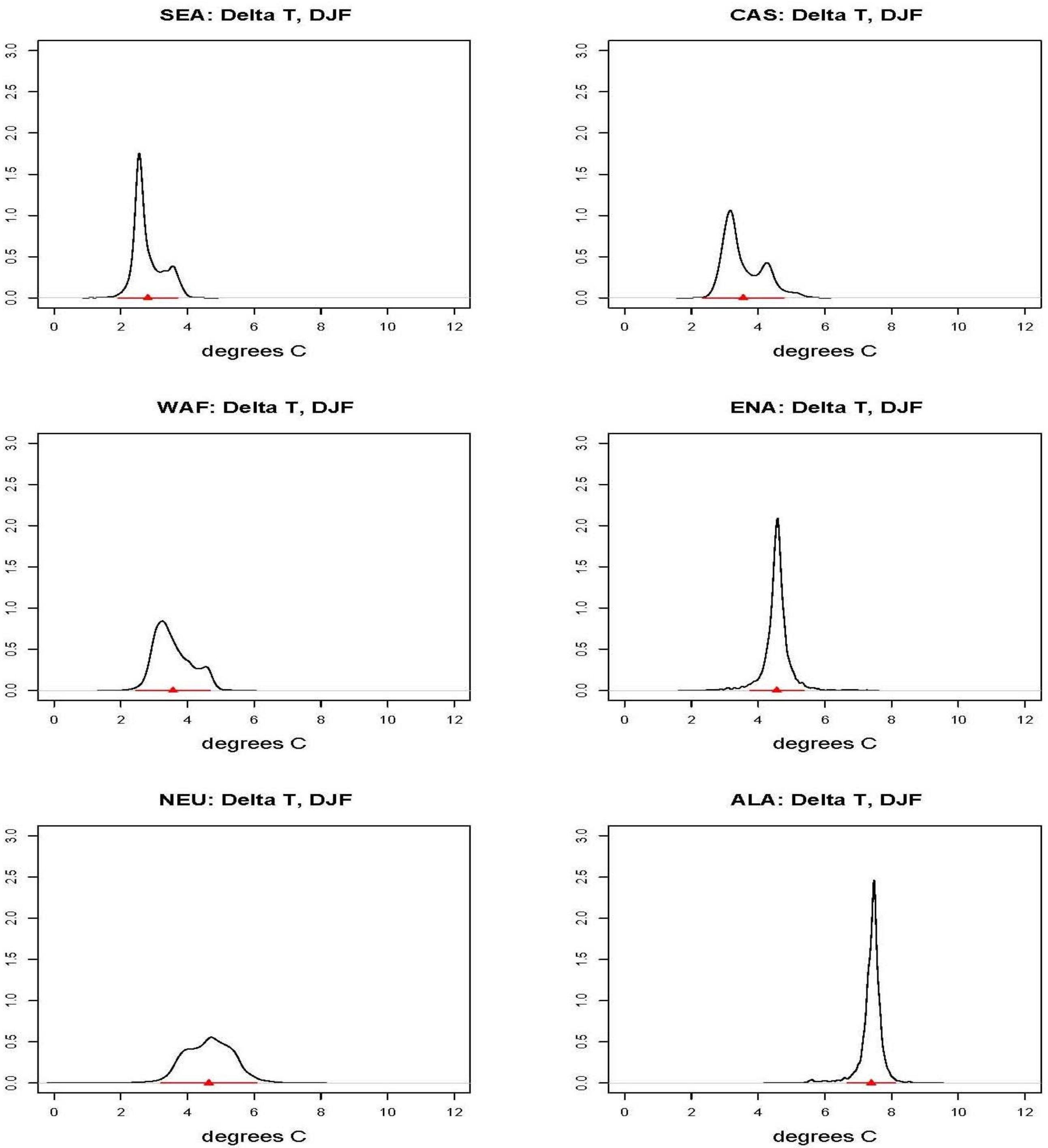
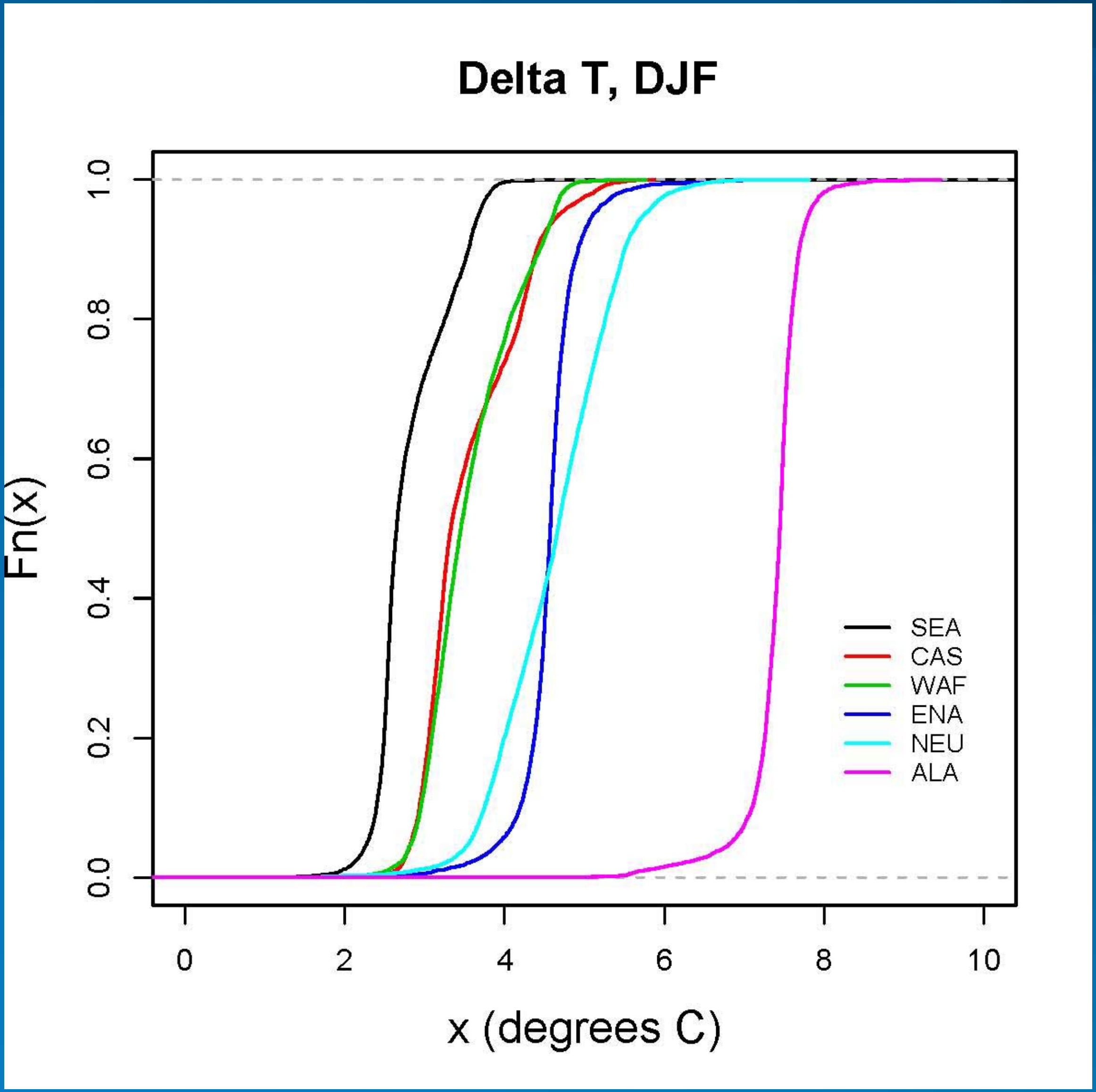


Inference for the Mean Temperature Change

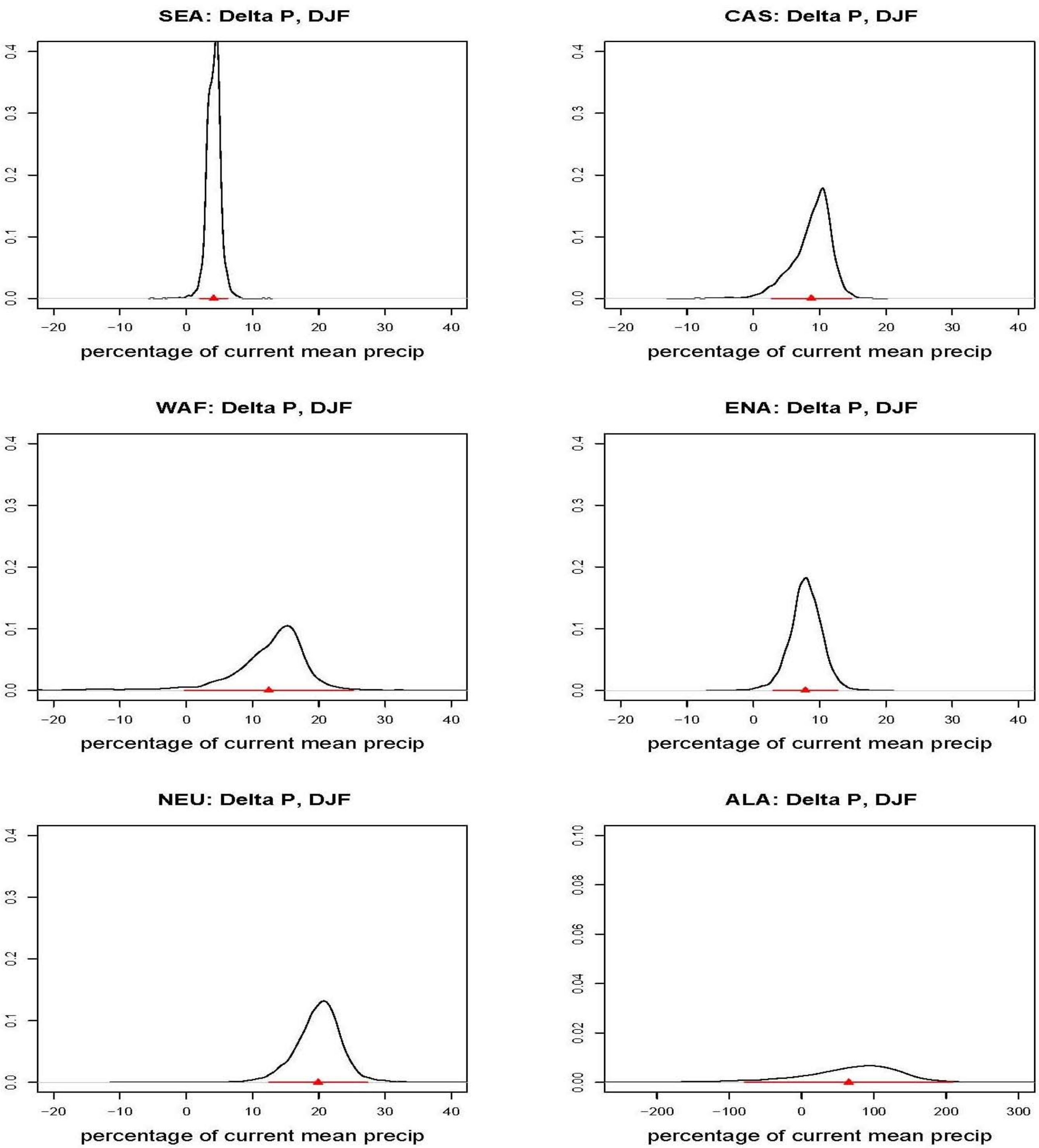


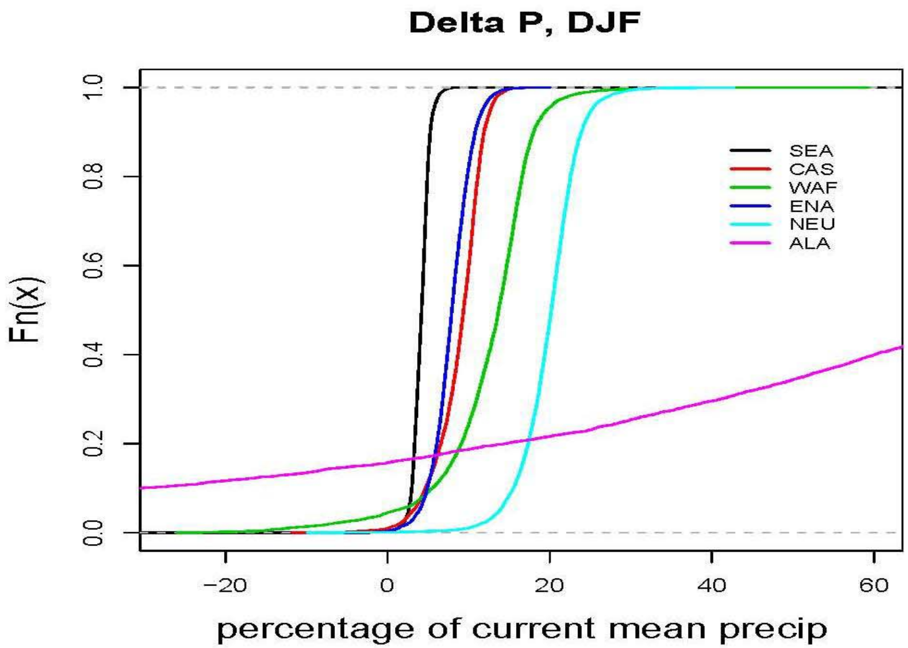

SEA: Delta T, DJF
CAS: Delta T, DJF
WAF: Delta T, DJF
ENA: Delta T, DJF
NEU: Delta T, DJF
ALA: Delta T, DJF
0.0 0.5 1.0 1.5 2.0 2.5 3.0
0 2 4 6 8 10 12
degrees C



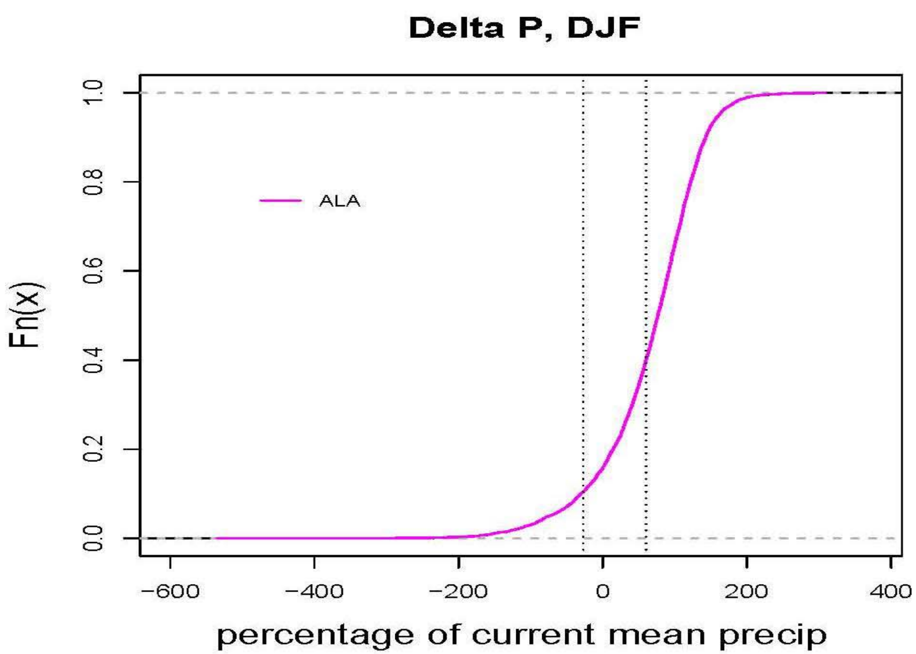
Delta T, DJF
Fn(x)
0.0
0.2
0.4
0.6
0.8
1.0
0
2
4
6
8
10
x (degrees C)
SEA
CAS
WAF
ENA
NEU
ALA

NCAR


SEA: Delta P, DJF
CAS: Delta P, DJF
WAF: Delta P, DJF
ENA: Delta P, DJF
NEU: Delta P, DJF
ALA: Delta P, DJF
0.0
0.1
0.2
0.3
0.4
0.00
0.02
0.04
0.06
0.08
0.10
−20
−10
0
10
20
30
40
−200
−100
100
200
300
percentage of current mean precip



Delta P, DJF
Fn(x)
0.0
0.2
0.4
0.6
0.8
1.0
SEA
CAS
WAF
ENA
NEU
ALA
−20
0
20
40
60
percentage of current mean precip



Delta P, DJF
Fn(x)
0.0
0.2
0.4
0.6
0.8
1.0
ALA
−600
−400
−200
0
200
400
percentage of current mean precip

Bayesian Model Extensions

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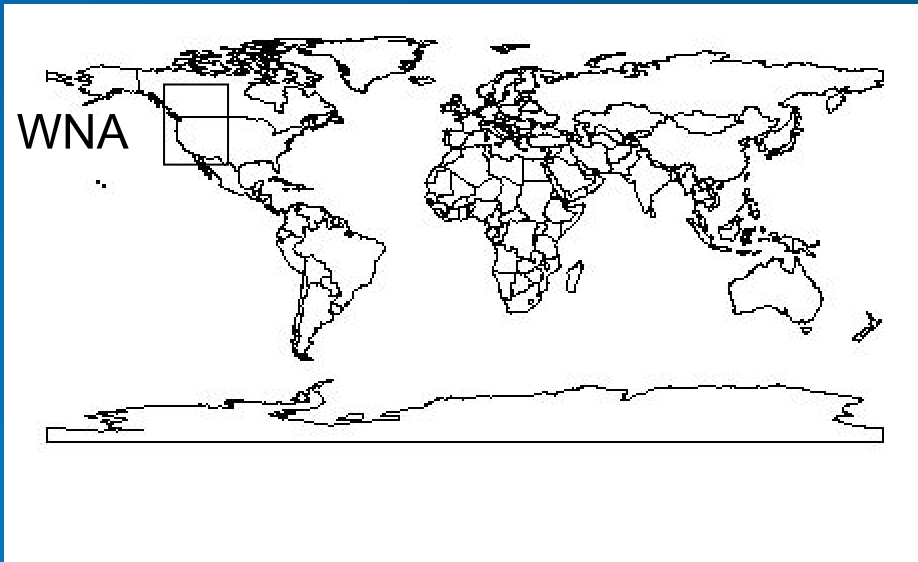
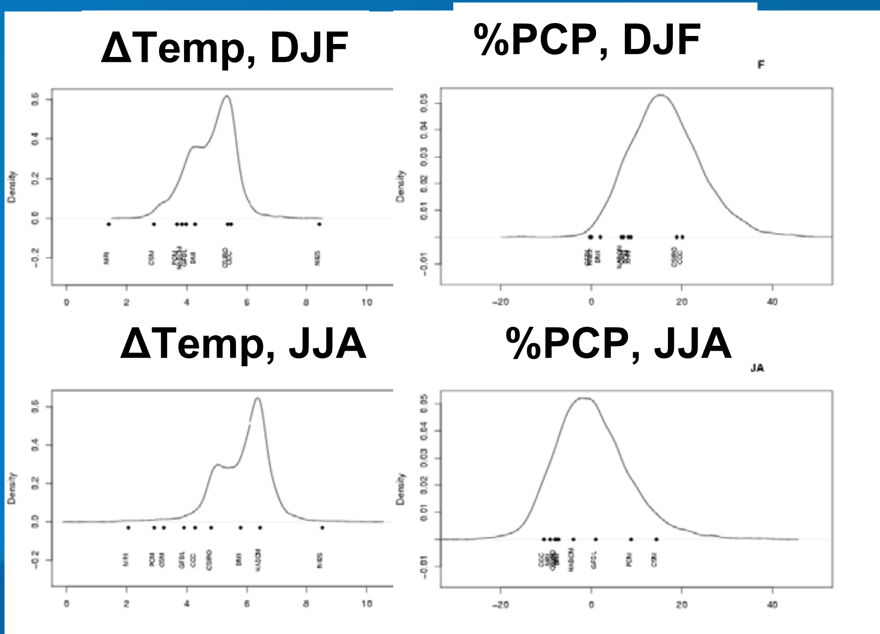
- Bivariate model – temperature and precipitation
- Inclusion of spatial correlation
- Perfomance on grid point level
- Application of expert judgement for formulating priors and for establishing correct weights for bias and convergence

Global





Statistical Downscale
(Yates et al. 2003)

Regional